Texas Climate Change

Observing Climate Change in Texas and the Goals of the US Climate Change Science Program

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Abstract

The Texas Climate Change Team was formed to establish a clear understanding of the goals of the U.S. Climate Change Science Program. The project goals identified support three of twenty-one synthesis topics from the CCSP. The selected synthesis topics are:

- Reanalysis of historical climate data for key atmospheric features and their implications for attribution of causes of observed changes
- Aerosol properties and their impacts on climate
- State-of-the-sciences of socioeconomic and environmental impacts of climate variability

Three objectives evolved from these goals are:

- To investigate claims of climate change in the state of Texas
- To determine possible correlations between weather patterns and pollution; and
- To study the effects of drought on local agricultural economies in Texas

Relevant areas of research focus included climate history, weather anomalies, crop production, and regional terrain. The team collected land cover, elevation, vegetation, and precipitation data for Southern and Western Texas from NASA missions through the alliance of Distributive Active Archive Centers (DAACs). The data was input into NASA-recognized models. The team evaluated predictive models whose outputs will help to create visualizations.

The project's pilot products were a technical paper and a 3-D visualization using the remote sensing data. The visualization will address team goals and may be used to augment decision support tools by community policymakers. The team will present project results to members of the CCSP upon completion.

1. Introduction and Background

Prior to beginning the research on the project, the team identified three goals that need to be achieved for a successful project. The team correlated these goals with the synthesis topics set forth by the US Climate Change Science Program. These goals included, first, to research evidence of climate change, which essentially asks the question: is the climate actually changing in Texas? Second, the team wanted to determine the effects of pollution and energy usage on climate, if any. Studying energy usage and outputs as well as studying data from the Measurements of Pollution in the Troposphere (MOPITT) instrument would achieve this goal. Third, the team would investigate the agricultural economic aspects of climate change, an extremely important part of the Texas economy. Drought would detrimentally impact the agricultural lifestyle of Western and Southern Texas. Therefore, the team conducted extensive background research on Texas agriculture.

1.1 Texas Agricultural Information

Texas is divided into ten regions: High Plains, Low Rolling Plains, North Central Texas, South Central Texas, Edwards Plateau, Upper Coast, Trans Pecos, East Texas, Lower Valley, and South Texas. Each region has a distinct climate and other physical characteristics that are ideal for specific crop production. The High Plains has a continental climate, which includes cold winters and low humidity. The climate in this region supports wheat, grain, alfalfa, sorghum, vegetables, cotton, and peanuts while the Low Rolling Plains region yields cotton, wheat, alfalfa, peanuts, and oats.

Wet weather is common in the East Texas and the Upper Coast regions. The East Texas region produces poultry, dairy, and cotton. Similarly, the Upper Coast region produces cotton. North Central Texas, South Central Texas, and Edwards Plateau make up Central Texas. This area produces cantaloupe, honeydew melon, cotton, and vegetables. The vast region is comprised of savannas, forests, and prairies. Specifically, Edwards Plateau is flat, except for certain sections that were lowered by erosion from the Llano, San Saba, and Padernales Rivers. South Texas is known for the production of cotton, sorghum, hay, vegetables, cantaloupe, honeydew melon, and peanuts. The Lower Valley is an agricultural region that contains soils that support the production of citrus, watermelon, cantaloupe, sugarcane, grain, cotton, and vegetables. The Trans-Pecos region, which includes El Paso, has an arid climate with an average precipitation of 11.65 inches. This region produces cotton, alfalfa, cantaloupe, honeydew melon, onions, and peanuts.

Tables 1,2, and 3 in the appendix display Texas crop progress, Texas crop condition and Texas topsoil moisture as of July 11, 2004.

2 Approach

Since each region of Texas has different climate conditions, a project studying the entire state would be difficult to manage. For this reason, the team decided to limit the study to two regions. The Trans-Pecos region of West Texas was selected because the community is very concerned about existing drought conditions. The team found information on climate history, weather events, crop production, geography, and the economy. Some weather data reflected rainfall statistics for El Paso, the largest city in West Texas. Other research tasks included reading about Earth Observation Satellites and the highlights of the CCSP Strategic Plan.

Since the majority of the data that DEVELOP teams use contains geo-spatial referencing, learning to use geographic information system (GIS) software was vital when presenting data graphically. This data came from the Earth Observing System (EOS) of NASA missions. Once the team became familiar with the EOS, the group identified Landsat 7, the Shuttle Radar Topography Mission (SRTM), Terra, and the Tropical Rainfall Measuring Mission (TRMM) as missions most applicable to the project. The team selected land cover data from Landsat 7 and elevation data from SRTM. Using GIS modeling programs such as ERDAS, these data layers can be combined to form a three-dimensional landscape of the area.

Terra and TRMM gain measurements on geophysical parameters such as atmospheric temperature, vegetation dynamics, and global precipitation. Two instruments aboard Terra are the MOPITT instrument as well as the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument. The measurements were data that could be used as inputs for climate prediction models. The model most important to this project is the Carnegie Ames Stanford Approach (CASA) Model, which will be explained in more detail in the next section. The team collectively analyzed the model outputs, research findings, and statistical data to draw conclusions. The final challenge was to create an effective visualization that will display and demonstrate the research results.

After collecting most of the data for West Texas, the team expanded the scope of the project to include the Rio Grande Valley of South Texas. The objective was to compare the climate situations of these two regions. The team obtained data for Southern Texas from the same sources as the data obtained for Western Texas. Expectations were to gain a better overall understanding of climate in these two regions of Texas.

3 Equipment, Facilities, and Models

The majority of the research for this project was performed on six IBM compatible PCs. Microsoft PowerPoint aided in producing project presentations and Microsoft Word was used to word process the technical paper. In addition, graphs and charts were produced using Microsoft Excel. The team obtained remote sensing data from the five major sources previously mentioned: the Landsat 7 mission, SRTM, MODIS aboard the Terra mission, MOPITT aboard the Terra mission, and TRMM. These remote sensing data were analyzed using the ERDAS IMAGINE 8.7 GIS program and the ArcGIS 8 program. Visualizations used in presentations were produced using the Macromedia Flash 5 moviemaking program. These three programs were run on two customized PCs. The Information Technology Team at Develop built these computers. Each has an ASUS K8V motherboard, 1 gigabyte of PC3200 DDR memory, an AMD 64bit 3000+ processor, a GeForce FX 5200 graphics adapter, and 60 gigabytes of Serial ATA hard drive.

Other useful programs that the team found included five programs used to view data files in hierarchical data format (HDF). These included the Orbit Viewer, iKompsat, NCSA HDFView 2.0, EGA, and HDF Browser 1.2. Graphics used for presentations and visualizations were modified using two programs: Gimp 2.0 and Paint Shop Pro 5. Two additional movie and animation programs used were Maya 5 and Bryce 5. The team also completed training on GIS programs from the Earth Science Research Institute (ESRI) prior to starting work on the project.

3.1 Modeling

An essential part of every project at DEVELOP is the system components framework developed by the NASA Earth Science Enterprise. Part of this framework is transferring remote sensing data into NASA supported models. Many of the supported models can be found on the ESE system components coin chart online (*Earth Science Enterprise*). The models on the coin chart were researched to examine whether or not they applied to the project. One objective of the Texas Climate Change Project was to incorporate a climate change model into the project. However, the NASA supported models associated with climate change demand very large datasets and require the use of super computers. These data sets came from the NASA missions identified in Section 2 and were analyzed using GIS programs. The team was unable to complete this part of the project and recommends that this be a part of the continuation project.

CASA, the NASA model already identified, will have strong relevance to the project. This modeling system was developed by the Ames Research Center and Stanford University. According to the system components website, the primary purpose of CASA is to model global terrestrial greenhouse gas emissions (*Earth Science Enterprise*). One output of the CASA model is the measure of net primary productivity (NPP). NPP is the net accumulation of carbon in terrestrial plants or the measure of carbon uptake in a region. This kind of output would be very helpful for the project because it would help quantify the amount of vegetation in Western and Southern Texas. Not only could the team use this model to compare and contrast these two regions, but also future vegetations predictions are possible. Using rainfall data from the TRMM mission, the team can potentially make climate predictions for Texas in the future. The team can then input the attributes of these predictions into the CASA model, and it will output NPP measurements for the future. Mr. Chris Potter, of the NASA Ames Research Center, is in charge of running the model on a Linux based computer at NASA Ames. The team requested to Mr. Potter that the CASA model be run using the data the team had collected.

Other models researched include the Land Surface Modeling System (LSMS) and the Automated Geospatial Watershed Assessment Tool (AGWA). However, the team concluded that the information gained from these models would not provide major advances in the task to better predict climate change. The Hydrologic Unit Model for the United States Model

(HUMUS) was another model of interest. HUMUS is a hydrology model that consists of a Geographical Information System that provides data on soils, land use, and climate. This model could be directly applied to climate change and is a model future teams can use to aid the project. Upon further research, HUMUS is a model that future teams could use to make better climatic predictions.

4 Current Findings

4.1 Remote Sensing Data Sources

Throughout the development of the project the team has collected a large amount of data. Fortunately, all of the data has come at no cost from a number of different sources. The team's policy was "if it is available and the team could use it later, go ahead and get it now." The theory behind this policy is that there might not be time later to wait for a three-day download. All of the remote sensing data was from the NASA missions: Terra, TRMM, Landsat 7, and SRTM. The team used the Global Land Cover Facility at the University of Maryland College Park to retrieve Landsat imagery. This imagery gives a true color image of the focus regions. The US Geological Survey Seamless Distributed Active Archive Center (USGS DAAC) was the site used to retrieve SRTM data. SRTM gives a digital elevation map (DEM) of the particular regions chosen. Using ERDAS IMAGINE 8.7 to project the Landsat imagery over the SRTM data the team created a 3-dimensional model of the regions of Western, and Southern Texas. The team used the MODIS instrument to acquire the vegetation index for dates over the course of the past four years. In accordance with the download policy the team retrieved all of the layers in the download from the MODIS instrument. The only layer used at this time was the 16-day Normalized Difference Vegetation Index (NDVI). The team took a regional section of the national NDVI image for several different time periods and Flash 5 aided in the animation of the different images to show a time-lapse movie of the vegetation index. The TRMM mission is a key to this project. Information retrieved from the TRMM mission gave the total rainfall in a region for specified period of time. Again, Flash 5 aided in making an animation of the monthly total rainfalls from January 1998 to December 2003. This animation showed the trend of rainfall over the years from 1998 to 2003. This is especially good because 1998 was one of the worst droughts on record for the state of Texas. The visualizations will aid the team in being able to predict possible trends in rainfall, temperature, vegetation, and pollution in and around the region. There are also many other data sources the team currently is investigating. However, these data sources will not be used in this project term but may be used in the future.

4.2 Local Climatic Data

Thorough research of the factors affecting climate in the areas of West and South Texas has shown several key trends. El Paso and Corpus Christi were used as the main reference points for West and South Texas respectively because the weather stations in both cities provide easily obtainable data. The Environmental Protection Agency (*Climate Change and Texas*) states that global mean surface temperatures have increased 0.6 – 1.2^{o} F between 1890 and 1996, and West and South Texas are no exception (*Climate Change and Texas*). Between 1895 and 2003 the average annual temperature in Corpus Christi has increased 0.648^{o} F and El Paso has increased 0.864^{o} F (*U.S. Climate at a Glance*). These trends are illustrated in Figure 1 in the appendix.

Another data trend found is the average annual precipitation for both Corpus Christi and El Paso (Figure 2). Using precipitation data from local weather stations the overall average from

1895 to 2003 is 0.41 inches with a downward trend of -0.01 inches per decade. Figures 1 and 2 were obtained from the National Oceanic and Atmospheric Administration's National Climatic Data Center (*U.S. Climate at a Glance*)

Corpus Christi has an upward trend of 0.05 inches of precipitation per decade and an overall average from 1895-2003 of 1.41 inches (Figure 3). These figures show that in general the precipitation amount is much greater in Corpus Christi as opposed to El Paso. Corpus Christi's average precipitation is 3 to 4 times as much as El Paso. Also, the data shows that over this time frame the average precipitation per year in Corpus Christi has increased. The opposite is true in El Paso.

When comparing the precipitation data from the NCDC weather stations in El Paso and Corpus Christi to accumulated rainfall totals measured by the TRMM mission, there is an apparent discrepancy (Figures 4 and 5). Several factors can be attributed to this difference. For example, there were different instruments used to take measurements, and therefore different associated errors. Also, locations of where data were collected were inexact. The TRMM mission did not start recording data until 1998 so only 7 years can be compared.

From the information in the figures, there is as much as an 8-inch difference between the data sets for El Paso and yet the figures for Corpus Christi are somewhat similar.

4.3 Effects of El Nino and La Nina on Climate

El Nino, or the warming of water in the Eastern Pacific Ocean, has affected the county of El Paso in the form of an El Nino-Southern Oscillation (ENSO) event. ENSO events occur in 4 categories of strength with category 1 being very weak and category 4 being strong. For 15 out of 24 ENSO years during autumn and spring seasons, El Paso received greater than normal precipitation (http://www.srh.noaa.gov/elp/papers/elp97-2.html) (Figure 7). A direct positive effect is seen in El Paso seasonal precipitation totals during moderate to strong ENSO events (http://www.srh.noaa.gov/elp/papers/elp97-2.html).
Based on this information, El Nino does not contribute to drought in El Paso, Texas.

Although El Nino has increased the rainfall in El Paso, Texas, La Nina has caused a decrease in rainfall. Between 1886 to 1988 there were 26 La Nina years (http://www.srh.noaa.gov/elp/papers/elp98-1.html). Figure 8 shows the 26 La Nina years along with their various rainfall percentages. From Figure 9, one can clearly see differences in annual rainfall during La Nina years and non-La Nina years. The lack of rain during this time contributes to crop losses, wildfire and water supply problems <http://www.twdb.state.tx.us/publications/newsletters/waterfortexas/wftwinter99/article3.htm>. The results of these findings show that the climate effects related to La Nina are directly opposite those of El Nino. Based on this information, one can see that La Nina can contribute to drought in El Paso, Texas.

4.4 Energy Consumption and Pollution Effects in Texas

Energy in Texas is primarily consumed in the form of petroleum, natural gas, coal and nuclear energy. In the United States, Texas ranks first in the consumption of petroleum, natural gas, coal and electricity (http://www.texasep.org/html/nrg/nrg_1con.html). Figure 6 shows the primary sources of energy per trillion btu or British thermal unit (Figure 6).

To help conserve energy, Texas plans to make use of renewable forms of energy from the sun, wind, hydroelectric plants and biomass/landfill gas. Wind can provide large amounts of electricity, and provides an alternative to burning fossil fuels. This is evident since fossil fuels tend to create air pollution and carbon dioxide, which can have detrimental effects on the climate. Pollution will be examined later in this section. Solar energy helps to slow global warming and it is stored in photovoltaic energy plants. Solar power plants are most useful to the western counties of Texas since sunshine is plentiful there. Hydropower is also nonpolluting and is a reliable form of power. However they can destroy aquatic habitat and free flowing streams that provide recreational opportunities and freshwater inflow to Texas' bays and estuaries. Biomass energy is produced from converting garbage to methane, burning materials to produce heat to generate electricity, and fermenting agricultural waste to produce ethanol. If all of the energy from biomasses could be recovered, it would be sufficient to generate two-thirds of all of the electricity used in Texas (http://www.texasep.org/html/nrg/nrg_3rnw.html).

Energy can be made more efficient if the current daily usage is changed. For example, cooling units use about one-third of all the electricity used by Texas residential customers. Efficient irrigation systems are beneficial to conserve water. Because of this, many Texas cities are promoting drought tolerant low water use residential and commercial landscaping. Using energy efficiently can benefit not only the annual budget, but also the climate as various forms of pollution are reduced.

Another important concern as to a possible cause of climate change is atmospheric pollution. Texas, like all states, is full of manufacturing companies. These industrial plants can cause air pollution. Although the Texas Clean Air Act of 1971 is meant to regulate how much pollutant each plant releases, Texas is still the "No. 1 most polluted state in America," according to former vice president Al Gore (http://www.ncpa.org/pi/enviro/pd061300a.html). The Texas Clean Air Act does very little in improving the air due to the fact that many coal plants were "grandfathered" from the requirement. These plants were exempt due to their existence prior to the law's passage. The grandfathered plants make up a third of Texas' industrial air pollution (http://www.uhh.hawaii.edu/~wswearin/Air_Pollution_in_Texas_ex.html). Other manufacturing plants along with the grandfathered plants contribute to serious air quality problems in Texas. Texas is ranked in the top eight of millions of pounds of toxic air emissions when only including manufacturing industries. Texas is also included in the top eight when accounting for all industries combined as shown in Table 4 in the appendix (http://www.texasep.org/html/air/air_4iss.html). In addition to not meeting Federal standards for ozone, Houston has topped Los Angeles as the metropolitan area with the highest ozone levels in the nation (http://www.texasep.org/html/air/air.html).

Texas is full of toxic releasing industries that constantly disturb the global environment by way of stratospheric ozone depletion in addition to the green house effect. These toxins also affect human health and cause acid rain, which takes its toll on local ecosystems. Table 5 in the appendix illustrates the amount of toxic air exact industries release (http://www.texasep.org/html/air/air_6maj_man.html).

Another pollutant that causes problems is carbon dioxide, produced as a result of fossil fuel burning. This pollutant can prevent heat from the sun from leaving the atmosphere into space (http://texasep.org/html/air/air_4iss.html). These potential causes of climate change cause for legitimate concern for the people of Texas.

5 Conclusion

At the time of this paper, the team has not come to a conclusive result as to the future of climate change in Southern and Western Texas. Climate change is a very complex field of study and it is very difficult to prove climate change is actually occurring in the time span given to perform the project. However, the team can make the following recommendations to future teams who wish to take on the challenge of climate change. First, further research should be conducted on data sources and models. There can never be enough data available to study. Also, there are many more NASA supported models that can aid in climate research, with CASA being just one. The information that could be obtained from these data and model outputs could be extremely useful. Second, more research should be put into the effects of pollution. While the team was not able to find complete MOPITT data, there was plenty of information concerning emissions and energy usage. Levels of carbon dioxide are not at healthy levels. Third, to deal with the problems of carbon dioxide, future teams should look into the techniques of carbon sequestration. Carbon sequestration could be a way to reduce the amount of carbon dioxide in the atmosphere if it can be shown that it is a cause of climate change.

Acknowledgements

The Texas Climate Change team would like to thank all of our faculty mentors and advisors for all of their support in helping us with our project.

Appendix

Tables

Table 1

Crop Progress Table - July 11, 2004

Crop / Stage		Percent 2004	2003	Average 1999-2003
Corn	Silked	80	74	74
	Dough	52	61	59
	Dented	43	41	46
	Mature	9	15	20
	Harvested	1	1	2
Cotton	Planted	100	100	100
	Squaring	70	49	66
	Setting Bolls	24	21	22
	Bolls Opening	4	3	6
Peanuts	Pegging	52	34	50
Rice	Headed	54	55	67
Sorghum	Planted	95	95	97
	Headed	50	48	53
	Turning Color	41	41	41
	Mature	27	25	29
	Harvested	13	13	20
Wheat	Harvested	98	93	95
Other Field Crops	Planted	100	94	97
Sunflowers				
Other Field Crops	Harvested Oats	98	97	96

(This chart was taken from: http://nass.usda.gov/weather/cpcurr/tx-crop-weather)

Table 2

Crop Condition Table - July 11, 2004 (Percentages)

Item	Excellent	Good	Fair	Poor	Very Poor
Corn	47	40	11	1	1
Cotton	21	37	25	11	6
Peanuts	21	53	23	2	1
Rice	24	52	24	0	0
Sorghum	26	50	15	7	2
Range and Pasture	26	42	21	7	4

(This chart was taken from: http://nass.usda.gov/weather/cpcurr/tx-crop-weather)

Table 3

Top Soil Moisture by District - July 11, 2004 (Percent of Acreage) *

Condition	1-N	1-S	2-N	2-S	3	4	5-N	5-S	6	7	8-N	8-S	9	10-N	10-S
Very Short	0	18	8	9	2	1	0	0	52	14	0	0	0	2	0
Short	10	26	26	26	26	5	1	1	32	18	1	2	0	28	80
Adequate	85	42	63	65	71	67	70	64	16	64	70	86	60	63	20
Surplus	5	14	3	0	1	27	29	35	0	4	29	12	40	7	0

* High Plains: 1-N, 1-S; Low Rolling Plains: 2-N, 2-S; North Central Plains: 3, 4; East Texas: 5-N, 5-S. Trans-Pecos: 6; Edwards Plateau: 7; South Central Texas: 8-N, 8-S; Upper Coast: 9; South Texas: 10-N; Lower Valley: 10-S.

(This chart was taken from: http://nass.usda.gov/weather/cpcurr/tx-crop-weather)

Table 4:

INDUSTRIAL AIR EMISSIONS OF TOXICS IN TEXAS, SELECTED STATES/TERRITORIES, AND THE U.S., 2001		
STATE	MILLIONS OF POUNDS OF TOXIC AIR EMISSIONS, MANUFACTURING INDUSTRIES, 2001	MILLIONS OF POUNDS OF TOXIC AIR EMISSIONS, ALL INDUSTRIES, 2001
Ohio	50.7	121.3
North Carolina	36.2	115.1
Texas	87.1	102.8
Georgia	42.7	91.8
Pennsylvania	29.8	89.0
Florida	30.5	83.4
Tennessee	55.1	79.6
Indiana	38.8	77.8
	Top Eight	**760.9**
New Mexico	0.5	1.1
Virgin Islands	0.9	0.9
Rhode Island	0.7	0.8
Guam	0	0.2
Vermont	0.1	0.1
D.C.	0	0.4
N. Mariana Island	0	0.008
American Samoa	0.007	0.007
	Bottom Eight	**3.2**
TOTAL US	**934.8**	**1,679.4**

Table 5:

TOXIC AIR RELEASES BY TYPE OF INDUSTRY IN TEXAS, 2001	
Industry	**Releases**
Chemicals & Allied Products	45,557,130
Electric Utilities	14,885,329
Petroleum Refining & Related Industry	13,908,366
Stone, Clay, Glass & Concrete Products	4,567,255
Plastics and Rubber Products	4,421,044
Paper and Publishing	4,152,233
Primary Metal	2,288,470
Lumber & Wood, Except Furniture	2,232,995
Fabricated Metals	2,232,098
Food & Kindred Products	2,008,976
Transportation Equipment	1,498,981
Machinery	680,851
Petroleum Bulk Terminals	417,869
TOTALS	**102,748,862**

Table 6: Reproduced table from <http://www.srh.noaa.gov/elp/papers/elp98-1.html>

Average Seasonal Precipitation (in.) for La Niña Years vs. Non-La Niña Years			
Season	**Autumn**	**Winter**	**Spring**
La Niña Years	1.78	.87	.54
Non-La Niña Years	2.75	1.50	1.01
Seasonal Difference in percent from La Niña to Non-La Niña Years	**64**	**58**	**53**

Table 7**: Reproduced table from** <http://www.srh.noaa.gov/elp/papers/elp97-2.html>

Precipitation at El Paso and Percent of Normal during Category 3 and 4 ENSO Events					
Onset Year	**Category**	**Autumn Precipitation (in.)**	**Percent of Normal**	**Following Spring Precipitation (in.)**	**Percent of Normal**
1899	4	1.29	50	.69	78
1900	3	3.64	142	.99	113
1902	3	2.66	104	.98	111
1905	3	5.97	233	1.31	149
1911	4	1.78	70	1.23	140
1912	3	3.07	120	.43	49
1914	3	5.56	217	1.36	155
1918	4	2.08	81	1.32	150
1919	3	5.20	203	.39	44
1925	4	1.84	72	3.30	375
1926	4	3.46	135	.28	32
1929	3	2.05	80	.65	74
1930	3	1.53	60	2.68	305
1939	3	2.58	101	.47	53
1941	4	6.32	247	1.06	120
1953	3	.65	25	1.54	175
1957	4	3.19	125	2.71	308
1958	4	8.47	331	.52	59
1965	3	2.42	95	1.12	127
1972	4	3.18	124	.89	101
1973	4	.16	6	.53	60
1976	3	4.10	160	.23	26
1982	4	5.57	218	1.92	218
1983	4	3.33	130	1.04	118
Average		**3.21**	**130**	**1.15**	**130**

Table 8: Reproduced table from <http://www.srh.noaa.gov/elp/papers/elp98-1.html>

Autumn, Winter and Spring Season Precipitation (in.) and Percent of Normal During La Niña Events						
Onset Year	Autumn Precip	Percent of Normal	Winter Precip	Percent of Normal	Spring Precip	Percent of Normal
1886	2.48	99	0.22	16	0.54	61
1889	3.54	141	0.74	55	0.07	8
1892	1.27	51	1.15	86	2.59	294
1893	2.10	84	1.04	78	0.15	17
1903	3.52	140	0.02	1	0.06	7
1906	1.18	47	1.62	121	0.17	19
1908	0.57	23	0.35	26	0.77	88
1909	0.62	25	0.78	58	0.00	0
1910	0.29	12	1.62	12	1.29	147
1916	2.14	85	0.64	48	0.21	24
1922	1.71	68	2.14	160	0.38	43
1924	0.39	16	0.13	10	0.59	67
1938	2.50	100	1.01	75	0.90	102
1942	2.56	102	1.51	113	0.07	8
1944	1.96	78	0.76	56	0.64	73
1949	3.24	129	1.41	105	0.10	11
1954	1.25	50	0.66	49	0.44	50
1955	1.04	41	1.41	105	0.05	6
1956	0.44	18	1.34	100	0.52	59
1964	2.80	112	1.30	97	0.15	17
1967	1.86	74	2.36	176	0.95	108
1970	1.69	67	0.27	20	0.42	48
1971	2.17	86	0.94	70	0.04	5
1973	0.16	6	0.27	20	0.53	60
1975	2.43	97	1.49	111	1.04	118
1988	2.35	94	1.27	95	1.27	144
Average	**1.78**	**71**	**0.87**	**76**	**0.54**	**61**

Figures

Figure 1:

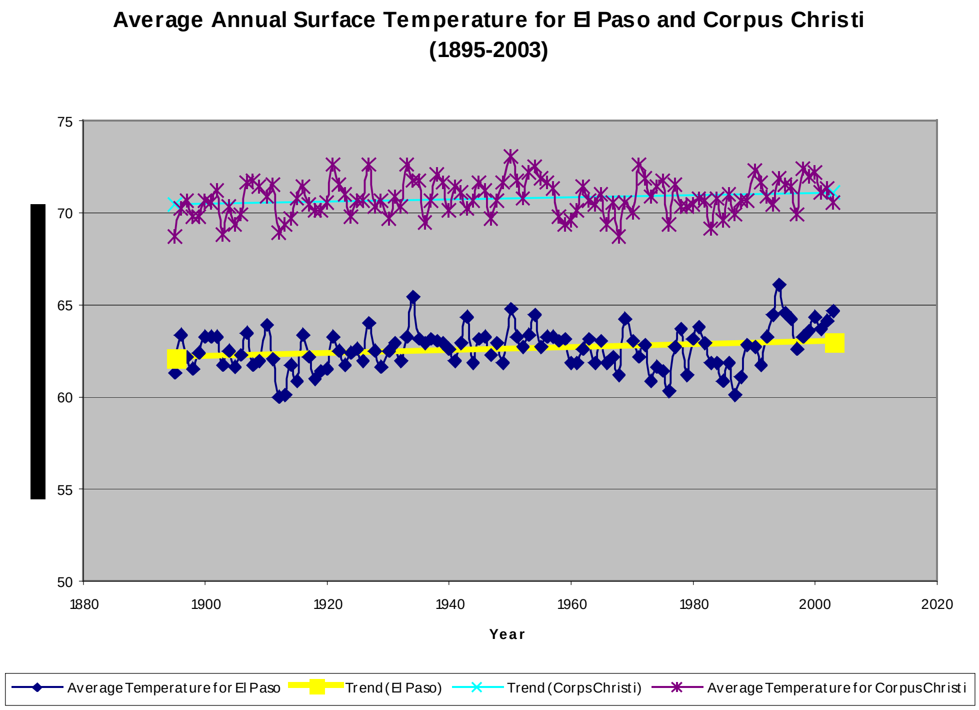


Figure 2:

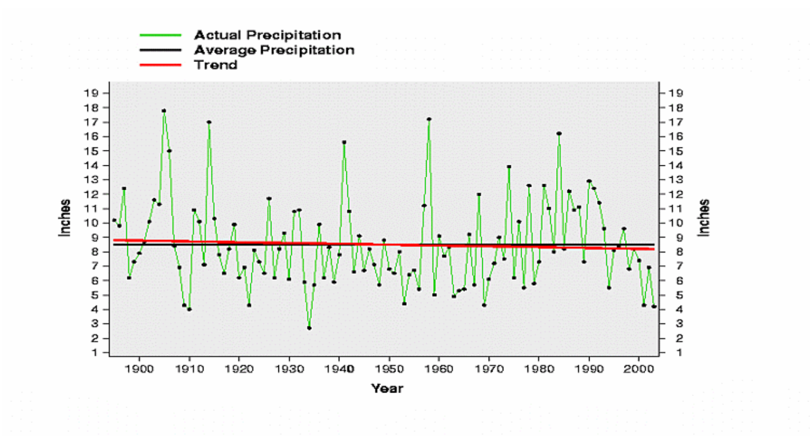


Figure 3:

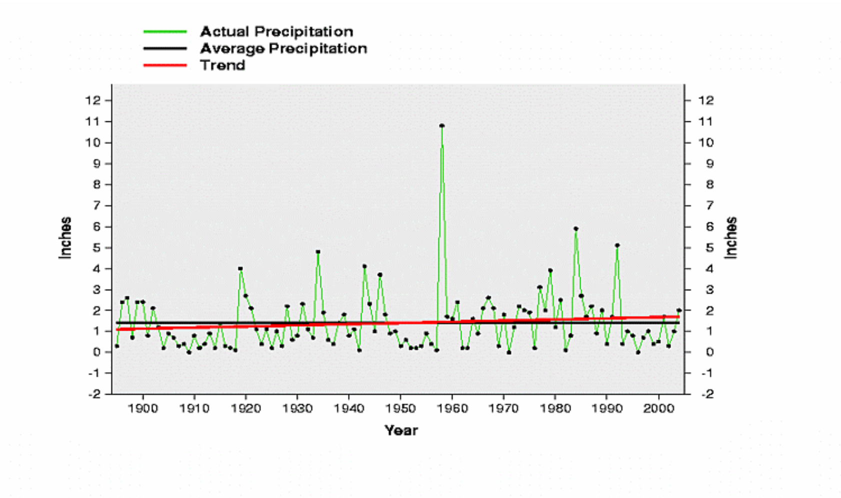


Figure 4:

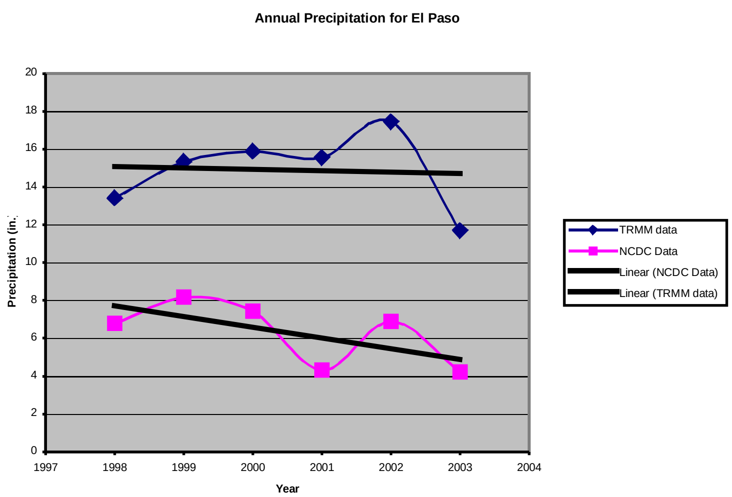


Figure 5:

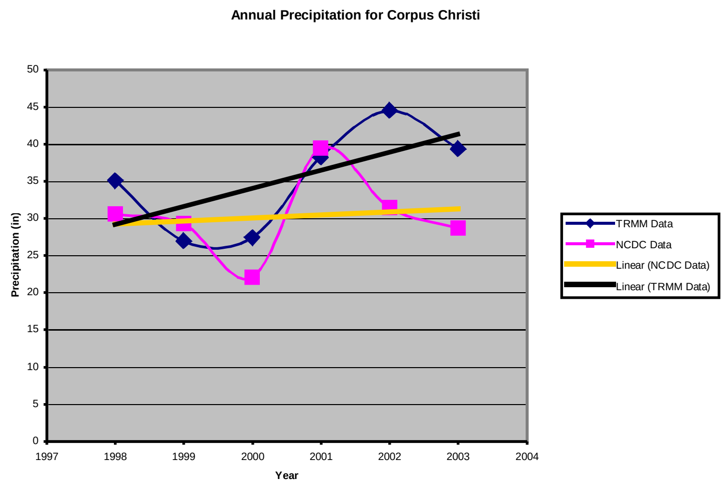
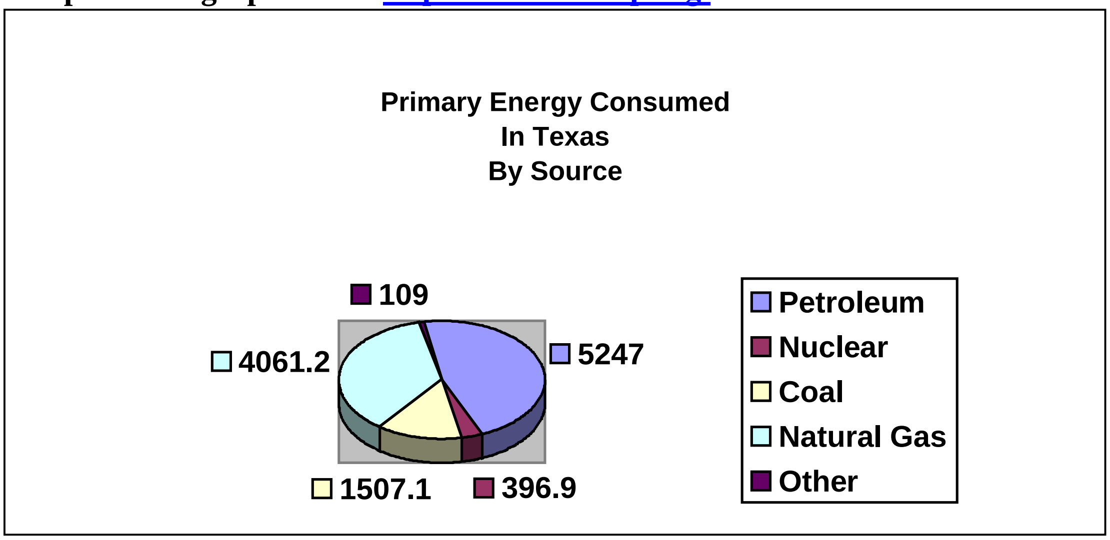


Figure 6**: Reproduced graph from <http://www.texasep.org/>**



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